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A preliminary biological survey of Port Hope harbour / Cook, W.

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REPORT
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A PRELIMINARY BIOLOGICAL SURVEY
of
PORT HOPE HARBOUR

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A PRELIMINARY BIOLOGICAL SURVEY OF PORT HOPE HARBOUR

by

W. Cook and D. Veal

BIOLOGY BRANCH

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SUMMARY

A preliminary biological survey was carried out in Port Hope Harbour in October, 1968, to evaluate the effects of discharges from Eldorado Nuclear Limited. Benthic community structures were evaluated to provide an indication of water quality, bottom fauna and plankton samples were analyzed for radioactivity (gross α, gross B, radium ^{226}), and fluoride determinations were conducted on the benthic invertebrates.

Results show that the effluents from Eldorado Nuclear Ltd., have impaired the benthic community within the harbour basin. Several pollutants have acted toward this impairment, but it is evident from this preliminary work that two waste materials, namely radioactive wastes and fluorides, are in the bottom invertebrates at undesirable levels. While radioactive concentrations in benthic organisms and plankton from harbour samples are high, comparisons with concentrations in organisms from control stations outside the harbour indicates that the radiological contamination is basically restricted to the harbour basin.

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RECOMMENDATIONS

1. Rigid control measures should be adopted by Eldorado Nuclear Ltd., to prevent radionuclides from being discharged to the receiving water. Fluorides and nitrogen compounds in the effluent from this industry should be kept down to a minimum. Fluorides in the receiving water should not be allowed to exceed 1.5 ppm.

2. Temperature studies in the area of confluence between the harbour narrows and Ganaraska River mouth should be undertaken to evaluate the possibility that fish migrations might be affected by a heated discharge from Eldorado Nuclear Limited.

3. If process wastes are to be discharged to the town sewers, studies should be undertaken in the vicinity of the sewage treatment plant discharge to evaluate the effects on the receiving water. A monitoring program measuring radionuclide and fluoride levels inside the harbour need not be undertaken unless future process wastes are to be directed to the harbour.

INTRODUCTION

Port Hope Harbour is located approximately 50 miles east of Toronto on the north shore of Lake Ontario. The harbour basin is about 400 feet wide, 600 feet long and 12 feet deep. The harbour narrows, which connects the basin to Lake Ontario at the mouth of the Ganaraska River (Fig. 1), is approximately 150 feet wide, 1000 feet long and varies in depth from 12 feet at the harbour basin to 25 feet at its south end. The harbour contains a mud bottom which is fairly uniform throughout the basin.

The harbour has had two primary uses, as an anchorage area for the Port Hope Yacht Club, and as a receiving basin for wastes from the uranium refining plant, Eldorado Nuclear Limited. This company, located on the west side of the harbour, had been discharging its cooling water and process wastes (including radium, uranium, HF, NH_4F) to the harbour at two locations (Fig. 1) until shortly after the time of the survey. Presently, the company has shut down its uranium refining operation and has recently put their new zirconium metal plant into operation. The company is also in the process of constructing a new UF6 plant which they expect to complete in about one year.

Eldorado Nuclear Ltd. plans to discharge their cooling water from these operations to the area of confluence of the harbour narrows and Ganaraska River mouth.

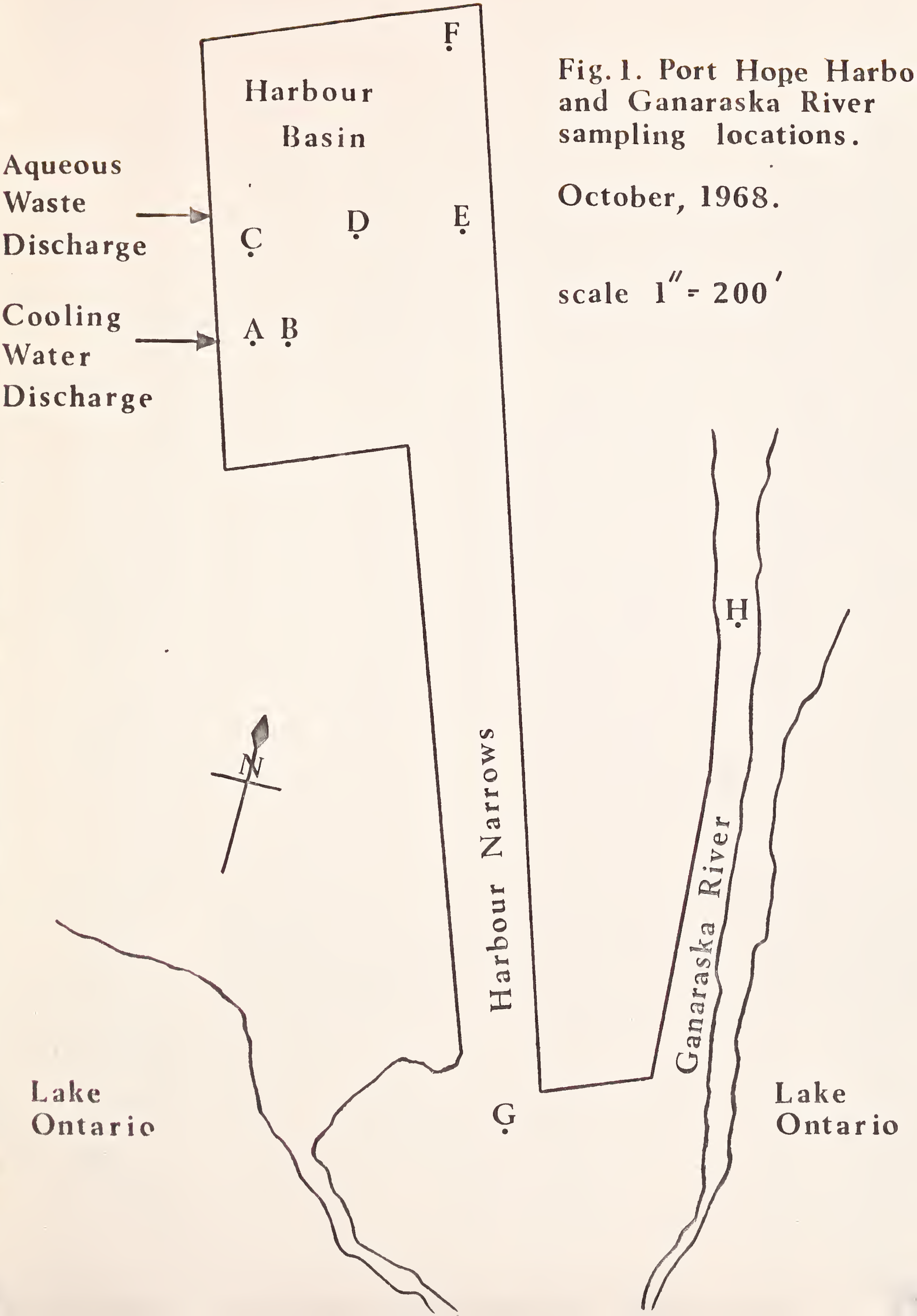

Fig. 1. Port Hope Harbour and Ganaraska River sampling locations.

October, 1968.

scale 1" = 200'

Process wastes will likely go to the town sewers.

Because of the danger of radioactive wastes to living organisms, the Biology Branch was requested to conduct a survey of the area. Unfortunately, field time was rather limited and only a brief preliminary survey was conducted in October of 1968.

THE EFFECTS OF RADIOACTIVE WASTES ON THE BIOTA

Radioactivity can result from various changes in the atomic structure of an element. Alpha (α) radiation is a result of high-velocity helium nuclei and beta (B) radiation is a result of high-velocity electrons. Through the loss of either alpha or beta particles, elements can change from one 'isotope' to another. Because of the structural similarity of the normal element and its radioactive isotope, organisms do not differentiate between the normal and radioactive forms of the same element and the absorption ratio of the two is approximately equal to the ratio of the two isotopes in the surrounding environment. The effects of radiation on an organism can be either somatic (directly affecting the individual cell and organism) or genetic (which do not apparently influence the individual but do affect is descendants). It is reported in Water Quality Criteria (McKee and Wolf, 1963) that "For genetic effects, however, there appears to be no possible threshold dose below which some effect may not occur. Any amount of

radiation, no matter how small, is bound to produce some mutations. Once completed, mutations are irreversible and almost all mutations are deleterious. Irradiation of a population from any source is bound to have some genetic consequences." It is therefore evident that radioactive wastes in the aquatic environment must be kept to a minimum.

SURVEY DESCRIPTION

Bottom fauna were sampled at six locations in the harbour basin, at one location just outside the harbour narrows, and at one location near the mouth of the Ganaraska River (Fig. 1). At each location, a composite macroinvertebrate sample was made from a collection of two to 15 Ponar dredge hauls, the numbers of dredges being dependent on collecting a sufficient weight of organisms for chemical and radiological analyses. The invertebrates were separated from the sediment using brass screens (24 meshes/inch, 0.65 mm. aperture) and preserved in a 10% solution of formalin. After specimen identifications, selected groups of organisms were sent to the Ontario Dept. of Health Laboratory for radiological analyses and to the OWRC Chemistry Branch for fluoride analyses. In some cases, the invertebrates from several stations were composited to provide a sufficient weight of organisms for analyses. Only those groups of organisms which were found in abundance were analyzed.

One plankton sample was collected inside the harbour basin, and one near Peter Rock located in Lake

Ontario about three miles east of the Harbour. At each location, a Wisconsin net (20-mesh) was towed in a horizontal position just below the water's surface for a 30-minute interval at about two miles per hour. The plankton samples were preserved in 10% formalin and were subsequently identified prior to being forwarded to the Ontario Dept. of Health Laboratory for radiological analyses.

RESULTS

Benthic Communities

Table 1 lists the average numbers of macroinvertebrates (in numbers/ft.^{2}) found at each sampling location. The benthic community within the harbour basin was characterized by high numbers of pollution-tolerant organisms, a small variety of organisms, and the absence of species which can live only in a clean-water environment. Station A, located about 50 feet from the former cooling water discharge of Eldorado Nuclear Limited (Fig. 1) was void of macroinvertebrates, indicating severe pollution in that area of the harbour. The macroinvertebrate population at station C, located approximately 50 feet from the company's aqueous waste discharge, consisted of only a few tubificid worms (2/ft.^{2}). The benthic community at B (100 ft. from the cooling water discharge) contained pollution-tolerant worms and midges. Stations D and E supported a slightly larger variety of invertebrates

Table 1. Benthic invertebrates (average numbers/ft^2) collected at Port Hope, October, 1968.

	A	B	C	D	E	F	G	H
TUBIFICIDS								
Limnodrilus cervix							278	220
hoffmeisteri		59		36				91
udekemianus					34	730		
Tubifex tubifex					51	102	570	
Aulodrilus pleuriseta							127	
Unidentified		210	2	56	740	4400	4700	445
CHIRONOMIDS								
Chironomus		132		36	190	166		400
Procladius				2		4		17
Glyptotendipes					4			
Anatopynia							6	
Orthocladiinae								8
ISOPODS								
Asellus					2	2	560	
AMPHIPODS								
Gammarus						2	21	4
SNAILS								
Physa						6		2
Lymnaea								2
TOTAL		401	2	130	1021	5412	6262	1189
Number of Dredges	2	3	2	15	5	5	3	3

indicating that the east side of the harbour is probably in somewhat better shape. Station F (north-east corner of the harbour) contained a wider variety of organisms than the other stations in the harbour basin, as well as the highest number of tubificids. Amphipods, pulmonate snails and isopods were found at this station as well as midge larvae and tubificid worms.

Plankton

Table 2 lists the plankton genera found at each of the two sampling areas. Interpretations of the plankton community structure is rather meaningless because of the inaccuracy of the collection method. It is interesting to note, however, that the plankton at Peter Rock (Lake Ontario, three miles east of Port Hope) contained six genera of zooplankton while the plankton collected inside the harbour basin contained only one genus (Table 2). This suggests that the zooplankton population in the harbour may be restricted as a result of pollution.

Radioactivity

Radioactivity (gross α, gross B, radium ^{226}) in the bottom invertebrates and plankton is illustrated in Table 3. Unfortunately, uranium analyses could not be carried out because of insufficient sample material.

Table 2. Plankton collected in Port Hope Harbour and at Peter Rock, October 16, 1968.

PETER ROCK

Phytoplankton	Zooplankton
Cladophora *	Daphnia
Staurastrum	Keratella
Oedogonium *	Asplandina
Pediastrum	Cyclops
Closteriopsis	Polyarthra
Ulothrix	Bosmina
Euastrum	
Aphanizomenon *	
Gloeotrichia	
Fragilaria	
Tabellaria	
Ceratium	
Eudorina	
Pandorina	
Chlamydomonas	
Asterionella	
Cymbella	
Microcystis	
Anabaena	

HARBOUR BASIN

Phytoplankton		Zooplankton
Cladophora *	Closteriopsis	Bosmina
Euastrum	Schroederia	
Oscillatoria	Scenedesmus	
Cocconeis	Lyngbya	
Gomphonema	Pediastrum	
Rhoicosphaenia	Staurastrum	
Diatoma	Gomphosphaeria	
Aphanizomenon	Nitzschia	
Tabellaria	Oocystis	
Cymbella	Cymatopleura	
Anabaena	Synedra	
Surirella	Pinnularia	
Oedogonium	Cyclotella	
Navicula		
Melosira		
Fragilaria		

* Abundant

Table 3. Results of radiological and fluoride analyses of invertebrates and plankton samples collected at Port Hope, October, 1968.

Station	Material	$pC_1\alpha$	pC_1B	pC_1Ra^{226}	$pC_1\alpha$ per wet gram	$pC_1\alpha$ per ml of ambient fluid	Fluoride as F (dry weight basis)
		per dry gram					
B	tubificids	12,000	13,000	460	1800	2	
D	"	1,700	2,100	130	240	0.75)	
E	"	830	1,200	68	130	0.4)	
F	"	640	790	87	90	0.25)	*0.02%
G	"	8	30	0.8	1	0.1	0.007%
H	"	5	10	1	1	0.03	0.005%
H	Chironomids	12	15	1.5	1	0.06	
B+D+E+F	"	1,400	2,200	110	160	1.1	
E+F+G	Isopods	28	55	5	4	0.09	
Harbour Basin	Plankton	160	2,300	3.5	20	0.07	
Peter Rock	"	1	11	0.2	0.1	0.1	

* Tubificids from stations D, E and F were combined for a fluoride analysis

Because the same group of organisms (tubificid worms) was analyzed at stations B, D, E, F, G and H, it is assumed that realistic comparisons between the stations can be made. The radioactivity in tubificid worms was lowest at station H (5 pC α, 10 pC B, 1 pC Ra ^{226}) and highest at station B (12,000 pC α, 13,000 pC B, 460 pC Ra ^{226}). Radioactive concentrations in worms throughout the harbour basin was high relative to the concentrations at the control station (H). If one assumes that the concentration in worms at the control station is normal, then the concentrations within the harbour ranges from 128 times to 2400 times the norm for gross α radioactivity, 79 times to 1300 times the norm for gross B radioactivity and 86 times to 460 times for radium ^{226} (dry weight basis). The radioactivity in tubificids at station G was similar to the concentration at station H, which suggests that the radioactive problem is basically confined to the harbour basin. Also, radioactive concentrations in the plankton samples were much higher in the harbour sample than in the Peter Rock sample (Table 3).

Fluoride

Tubificid worms from three areas were examined for fluoride content. A composite of tubificids from stations D, E and F. contained 0.02% (200 ppm) fluoride (as F), tubificids from station G contained 0.007% (70 ppm) and station H contained 0.005% (50 ppm) fluoride. If we assume the fluoride concentration at H to be the norm,

then the concentration in tubificids inside the harbour is four times the norm.

DISCUSSION

It is evident from the invertebrate samples collected that Port Hope Harbour contains water of poor quality. The high numbers of pollution-tolerant benthic organisms along with the small variety of invertebrate life is indicative of a polluted environment.

The harbour water has no doubt been impaired by several factors which additively deteriorate water quality. Because of the enclosed nature of the harbour basin, one would expect that little harbour-lake water exchange takes place, thus permitting a build-up of any waste materials entering the harbour. The harbour is relatively shallow (12 feet) and probably becomes quite warm during the summer, thereby stimulating the production of aquatic life. The former cooling water discharge from Eldorado Nuclear Ltd. would have aggravated this situation. The absence of macroinvertebrates at station A may have been a result of increased water temperature in that area.

Also, the harbour is used as an anchorage area for the Port Hope Yacht Club. Oil was noted in the sediment at several places in the harbour basin and one can assume that the boats are at least partially responsible for this problem.

Within the harbour basin, the benthic community structure became more normal with increasing distance from the former effluents of Eldorado Nuclear Limited. As mentioned earlier, the station nearest the cooling water discharge was void of macroinvetebrates and the station farthest from the discharges (station F) supported the best variety of life in the basin. This improvement in the bottom fauna structure from west to east within the harbour basin corresponds closely to a west to east decrease in radioactive concentrations in the tubificid worms (tables 1 and 3). It would therefore appear that radioactive wastes are at least partially responsible for this biological impairment. However, other waste materials from the outfalls of Eldorado Nuclear Limited (including temperature loading, NH_3, F) no doubt showed similar differences in concentrations from the west to east side of the harbour and added to the general deterioration of water quality. Fluoride concentrations in tubificid worms are quite high (table 3) and it is possible that the organisms have been affected by fluorides. Fluoride ions appear to have direct toxic properties toward aquatic life, and at concentrations of 2.3 - 7.3 ppm have been shown to kill trout in $18^{\circ}C$ soft water (McKee and Wolf, 1963, Water Quality Criteria). It is therefore important that fluoride concentrations in the receiving water be kept to a minimum (certainly below 1.5 ppm). *

It is interesting to note that most of the midge larvae at station B had deformed labial plates similar to those described by Hamilton (Brinkhurst, Hamilton, Herrington, 1968) at the western end of Lake Erie. Dr. Hamilton attributed the deformities he found to "the organism's reaction to unfavourable features of the environment", as it is difficult to pinpoint the specific pollutant responsible. In Port Hope Harbour, the deformities could be caused by one or a combination of several pollutants. Midge larvae with deformed labial plates are found periodically in organically polluted water and although chemical analyses of the water were not conducted in this survey, the benthic invertebrates certainly indicated organic pollution. However, because of the high levels of radioactivity found in the organisms and because even low levels can cause mutations, it is quite possible that the deformed labial plates were caused by radiation.

*

It is suggested in Water Quality Criteria (McKee and Wolf, 1963) that a fluoride concentration of 1.5 ppm will not affect aquatic life. The USPHS Drinking Water Standards of 1962 set a mandatory upper limit on fluorides of 1.5 ppm in areas where the annual average maximum daily air temperature is from 53.8 to 58.3°F.

FUTURE CONSIDERATIONS

The two effluents which were discharged to the harbour basin until late 1968 have been abandoned. Eldorado Nuclear Ltd. has recently completed a new zirconium metal plant and are presently constructing a new VF6 plant which the company expects to complete in 1970. Cooling water from these operations will be discharged near the confluence area of the harbour narrows and Ganaraska River. Plans are to have the process wastes discharged to the town sewers which in turn are discharged to Lake Ontario east of Port Hope. The water quality within the harbour basin should therefore slowly improve. However, because of the slow deterioration rate of radionuclides, the radiological problem will likely remain for some time.

The discharge of process wastes from Eldorado Nuclear Limited to the town sewer system would certainly be desirable from the standpoint of dilution and assimilation. The company should not consider this as a licence, however, to add poorly treated wastes to the town sewer system. Radioactive wastes released to the environment must be kept within stringent limits.

ACKNOWLEDGMENTS

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